

7.2.1 Compressor Horsepower-Hours

The two main types of compressor drivers in the industry are reciprocating gas engines and gas driven turbines. Two pieces of information are needed to calculate the activity factors, expressed as horsepower-hours (hp-hr), for the two types of drivers in each segment of the industry except production. These data are the installed horsepower and the average annual operating hours. For the production segment, horsepower-hour data was available for the activity factor calculation. Table 7-1 presents the necessary parameters and the resulting activity factors for both engines and turbines by industry segment. This table also includes the 90% confidence limits for each factor.

TABLE 7-1. COMPRESSOR ACTIVITY FACTORS FOR EACH INDUSTRY SEGMENT

| Industry Segment | Installed Engine MMhp ^a | Installed Turbine MMhp ^a | Annual Hours Engine | Annual Hours Turbine | Engine MMHp±hr | Turbine MMHp±hr |
|----------------------|--|---|---------------------------|----------------------------|-------------------|--------------------|
| Production | NA | NA | NA | NA | 27,460 ∓ 200% | NA |
| Processing | 4.19 ∓ 132% ^b | 5.19 ∓ 99% ^b | 6153 ∓ 15% | 6345 ∓ 48% | 25,780 ∓ 134% | 32,910 ∓ 121% |
| Transmission/Storage | | | | | | |
| X Operation | 10.2 ∓ 10% | 4.55 ∓ 10% | 3964 ∓ 14% | 2118 ∓ 31% | 40,380 ∓ 17% | 9635 ∓ 33% |
| Generators | 1.45 ∓ 23% | 0.045 ∓ 166% | 1352 ∓ 38% | 474 ∓ 620% | 1962 ∓ 45% | 21.2 ∓ 121% |
| X Storage | 1.33 ∓ 14% | 0.59 ∓ 14% | 3707 ∓ 23% | 2917 ∓ 620% | 4922 ∓ 27% | 1729 ∓ 626% |
| Generators | 0.085 ∓ 126% | 0.057 ∓ 184% | 191 ∓ 377% | 36 ∓ 620% | 16.3 ∓ 621% | 2.05 ∓ 1312% |

^a Does not include horsepower associated with gas lift for oil recovery or with electric drivers.

^b Average of two estimation methods.

To determine the horsepower and operating hours for engines and turbines, two major sources of data are available: the GRI/EPA methane project site visit/company surveys and the American Gas Association (AGA)/GRI/Southwest Research Institute (SwRI) compressor databases. The site visit/company surveys were used to determine horsepower and operating hours for the processing industry segment and for transmission and storage generators. The AGA/GRI/SwRI databases were used to determine horsepower for the transmission industry segment. Operating hours for the storage industry segment were based on data from the site visit/company surveys. Operating hours for the transmission industry segment were based on data from FERC.

The horsepower-hours for the production industry segment were determined using data provided by a major natural gas production company. A brief discussion of the development of each of the activity factors follows (for further details, refer to the compressor report "Estimate of Methane Emissions from Compressor Exhaust").⁴

Production--The production segment horsepower is based on horsepower-hour data from one company for 516 engine drivers. The database included drivers in the Gulf Coast (Onshore and Offshore) and Central Plains regions. The horsepower-hour data was regionalized and divided by the company's gas production for that region before scaling to a national estimate. National horsepower-hours was calculated using the 1992 marketed production for the entire United States (Natural Gas Annual, 1992)¹⁰. Confidence limits were rigorously calculated for the horsepower-hour estimate to be $\pm 576\%$. Due to questions regarding the completeness of the data provided, this uncertainty was considered to be too high and the confidence limits were set at $\pm 200\%$ based on engineering judgement.

Turbine compressor drivers do exist in the production segment; however, there was insufficient data available to perform an activity factor calculation and extrapolation. This emission source would not be a significant source due to the small number of these drivers in this industry segment and the low methane emission factor for turbines.

Processing--The processing segment horsepower was determined by extrapolating site visit data for ten gas plants. The average of two extrapolation methods was used. The first method extrapolates the site data to a national estimate by multiplying the total U.S. gas plant throughput as of January 1, 1993 (46,510.7 MMcfd, *Oil & Gas Journal* ⁶) by the site visit horsepower per throughput (47.8 hp/MMcfd for engines and 59.2 hp/MMcfd for turbines).

The second method extrapolates the data to a national estimate by multiplying a ratio of the 726 gas plants in the U.S. (*Oil & Gas Journal*) to the 10 sites visited. This second method uses a scaling factor of approximately 73 for processing horsepower and assumes that all gas plants have approximately the same throughput, despite the

variation found in the site data (40 MMcfd to 750 MMcfd). To provide a more conservative estimate, the two methods were averaged when calculating the national estimate for processing horsepower.

The annual operating hours were based on the ten site visits and data provided from two companies (18 additional sites). For eight of the sites visited, typical operating hours for each of the compressors were not available. Therefore, all compressors that were running during these site visits were assigned annual operating hours of 8760 and all compressors that were idle were assigned annual operating hours of 0. An average of the average operating hours per site was calculated to get the processing segment operating hours (203 engines and 9 turbines). Confidence limits were rigorously calculated for the horsepower and operating hours estimates from the variation of the data.

Transmission--Transmission losses from compressor exhaust have been broken down into two subsections: compressor stations and storage fields. For each of these areas activity factors were calculated for compressor drivers and for generator drivers.

Transmission Compressor Stations--The transmission segment horsepower for each compressor type was determined using the GRI TRANSDAT database. TRANSDAT has not been revised since the 1989 data were collected. Therefore, 1989 is used as the base year for this industry segment. Installed horsepower was taken from the Industry Database module of TRANSDAT (11.2 MMhp for engines and 5.0 MMhp for turbines). This horsepower accounts for about 97% of the gas utility industry installed 16.7 MMhp reported by AGA for 1989. AGA gathered data through a survey of their member companies, which included approximately 96% of total gas industry sales. The TRANSDAT horsepower was adjusted for the 1989 storage horsepower reported by AGA to give 10.2 MMhp for engines and 4.5 MMhp for turbines. Confidence limits for horsepower could not be rigorously calculated from the TRANSDAT database because the installed horsepower was given by installation, or site, and then summed to calculate a national estimate. Therefore, confidence limits were set based on engineering judgement.

The annual operating hours are based on data reported on FERC Form No. 2 for

the year 1992. The FERC database did not identify the type of driver, reciprocating engine or turbine. As a result, additional data from TRANSDAT and one transmission company was used to split the FERC hours between the two driver types. Confidence limits were rigorously calculated for the operating hours estimate from the variation of the FERC data.

Transmission Storage Fields--The storage segment horsepower (1,920,441 hp) came from *Gas Facts* for 1992. The split between engines and turbines was assumed to be the same as the engine and turbine split found in TRANSDAT (69.1% for engines and 30.9% for turbines). The horsepower data were gathered by AGA through a survey of their member companies, whose production makes up approximately 96% of total gas industry sales. Confidence limits for horsepower data were calculated based on an assumed $\pm 5\%$ uncertainty for the AGA horsepower and an assumed $\pm 10\%$ uncertainty for the TRANSDAT horsepower splits.

The annual operating hours are based on data provided for eleven storage stations (50 engines and 6 turbines). Confidence limits were rigorously calculated for the operating hours estimates from the variation of the data.

Transmission Generators--Generator driver horsepower was found both at compressor stations and at storage fields. The generator horsepower for compressor stations is based on the total installed horsepower for seven of the transmission sites visited and data provided by one company for 34 compressor stations (35,006 hp for engines and 1080 hp for turbines). To extrapolate to a national estimate, the horsepower per station was multiplied by the total number of transmission compressor stations in the U.S. (1700, FERC Form No. 2) ²⁴. This assumes that all transmission stations have approximately the same generator capacity despite the variation found in the site visit data (0 hp to 3500 hp). However, no other method of extrapolation was available.

The generator horsepower for storage fields is based on the total installed horsepower for one company with nine storage fields (3 engines and 1 turbine). To extrapolate to a national estimate, the horsepower per field was multiplied by the total number of storage fields in the U.S. (475, AGA *Gas Facts*). This assumes that on average,

all storage fields have the same generator capacity despite the variation found in the company data provided (0 hp to 1080 hp). However, no other method of extrapolation was available.

Generator annual operating hours were also provided by the same sources providing horsepower data. An average of the average generator operating hours per site was calculated to determine generator operating hours for compressor stations (87 engines and 1 turbine) and storage fields (2 engines and 1 turbine). Confidence limits were rigorously calculated for the horsepower and operating hour estimates from the variation of the site/company data except for the case of generator turbines. Since there was only one data point for both compressor station generator turbines and storage field generator turbines, confidence limits were assumed to be equal to that calculated for turbine compressor drivers at storage fields.

The final activity factors (Table 7-1), in horsepower-hours, were calculated using the national estimates for compressor horsepower and the average operating hours for each industry segment except for the production segment. Production horsepower-hours were estimated as described above. Activity factor confidence limits were propagated from the confidence limits for the individual terms using a standard statistical approach.